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Fencing for conservation? —The impacts of fencing on grasslands and the endangered Przewalski's gazelle on the Tibetan Plateau

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Dear Editor,

Grasslands in north-western China support six species of wild antelopes (Jiang et al., 1996). Among those, the Przewalski's gazelle (*Procapra przewalskii*) is endangered with a most restricted distribution range. This species is only found on grasslands around the Qinghai Lake in the north-eastern corner of the Tibetan Plateau (Jiang et al., 1995). While poaching of gazelles has been largely prevented since 2002, fencing, a measure supported by grassland conservation policies, has posed negative impacts on the gazelles (Zhang et al., 2014). However, agricultural departments argue that fencing is an effective measure to protect grassland thus list fence building as a criterion for evaluating grassland conservation and a key item of government investment, even though removal of fences has been suggested for wildlife conservation. Does fencing indeed contribute to grassland protection and restoration?

Zhang et al. (Zhang et al., 2014) showed that fence density was positively correlated with the MODIS–250 m Enhanced Vegetation Index (EVI) value, indicating that grasslands with a higher fence density had a larger biomass. This may be an evidence of fences' effect on grassland restoration. However, this phenomenon could alternatively be explained as more fences tend to be built on better grasslands. In order to verify whether high density of fences contribute to grassland restoration, we analyzed a ten-year (2000–2009) trend of grassland biomass within the current habitat of Przewalski's gazelles.

Our study area included all patches of grasslands where Przewalski's gazelles occurred around the Qinghai Lake (98.40°–100.90° E, 36.20°–37.60° N) except for the Bird Island, with a total area of ~1000 km^2. Grasslands within the entire region are winter pastures of local people, with fences having been built all around. Livestock are transferred to summer pastures away from this region from June to September. Parallel transects were conducted systematically in gazelle-occupied areas as well as adjacent non-occupied areas in 2009. Transects were divided into 1 km sections and buffered 500 m on each side to form 1 km^2 study cells . On transects we recorded each fence that was traversed, and all livestock encountered within 500 m on each side of the transect line (details could be found in Zhang et al. (Zhang et al., 2014)). The MODIS 250 m EVI was used as an index of grassland biomass since there is positive relationship between grassland biomass and EVI on the Tibetan Plateau (Yang et al., 2009). Every study cell contained ~16 EVI grids. We averaged the annual highest value of all EVI grids within one study cell and assigned the value to the cell as its annual EVI value. We then conducted a linear regression of annual EVI value and year for each cell. A cell would be categorized as biomass increase if its regression was significant (α=0.05) with a positive coefficient, or decrease if its regression was significant with a negative coefficient. Cells with non-significant regression were categorized as biomass unchanged. Fence density was

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calculated as the number of fences traversed on 1 km transect. The average fence density in gazelle occupied areas was 2.9±0.2 #/km, and 3.1±0.1 #/km in non-occupied areas (Zhang et al., 2014). Thus we categorized fence densities into low (0–3 #/km transect) and high (⩾4 #/km transect), and compared the average EVI values in the first three years (2000–2002) and the last three years (2007–2009) between cells with high and low fence densities, using Mann-Whitney test. Livestock density was calculated as dry sheep equivalent (DSE)km^{-2} (see Zhang et al. (Zhang et al., 2014) for details). The average livestock density in gazelle occupied areas was 246.4±23.1 DSE km^{-2}, and 225.6±23.4 DSE km^{-2} in non-occupied areas (Zhang et al., 2014). We then categorized livestock density into low (⩽200 DSE km^{-2}) and high (>200 DES km^{-2}) to indicate low and high grazing pressure. When controlling grazing pressure, chi-square test was used to determine whether the percentage of cells with significantly changed EVI value in cells with high fence density differed from the percentage in cells with low density of fences.

Only 15.5% of the 600 cells that we analyzed had a high density of fences. The average EVI value of cells with high fence density was higher than that of cells with low fence density, both in 2000–2002 (Mann-Whitney U=18812.5, P<0.01) and in 2007–2009 (Mann-Whitney U=19609.5, P=0.01, Figure 1). During the ten years, 91.3% of the cells had a non-significantly changed EVI value, whereas 4.2% of them had a decreased EVI value and 4.5% of them had an increased EVI value (Table 1). Cells which changed significantly in EVI value were mostly found near the lake shore, whereas only one cell was found in both Tianjun and Wayu. The percentage of cells with increased/decreased/unchanged EVI value in cells with high fence density was not different from that in cells with low fence density, no matter under high grazing pressure (X^2=0.740, P=0.691) or low grazing pressure(X^2=2.467, P=0.291).

Before making a conclusion from above results, a premise that fences and livestock in the study area did not change from 2000 to 2009 needs to be confirmed. To obtain such information, we conducted a total of 70 household interviews in 2008–2009, in five local communities within gazelle habitat. Results indicated that most fences were built from 1990 to 2000, as there were only 5 out of 46 interviewees stated that they firstly built their fences after the year 2001. Only 4 interviewees stated that they had more fences built during 2001–2008. Thus we can use fence density obtained from our surveys conducted in 2009 to stand for fence density in the past ten years. Meanwhile, 63% of the interviewees indicated no livestock change during 2000–2009 while 23% of them indicated a decrease of livestock, thus we could proximately use livestock data obtained in 2009 to stand for livestock in the past ten years.

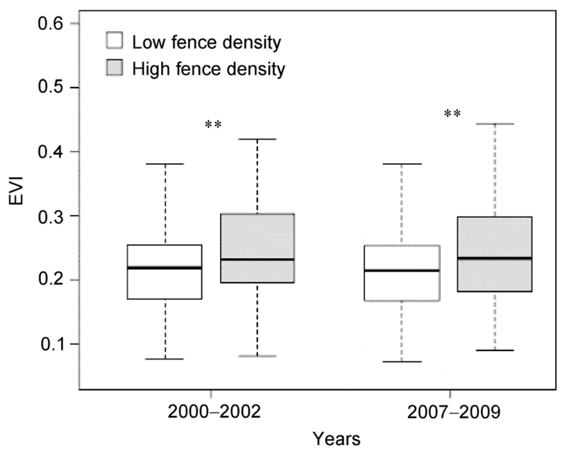

Figure 1 Three-year averaged EVI value of study cells with low and high fence density. **, comparison is significant at the 0.01 level (2-tailed)

Table 1 The number of study cells with increased/decreased/unchanged EVI during 2000–2009 within each category of fence density and livestock density

	Livestock_high	Livestock_Low
Fence density_high	4/1/39	1/4/44
Fence density_low	10/7/127	12/13/338

In conclusion, grasslands with a high fence density had a larger biomass in 2000–2002 than those with low fence density, and this pattern remained in 2007–2009. In addition, grassland biomass of most study cells did not change significantly during the ten years, no matter what fence density they had. The percentage of cells with increased or decreased biomass in cells with high fence density was not different from the percentage in cells with low fence density, no matter under what grazing pressure. All above results indicated that a high density of fences neither contributed to the recovery of grassland nor caused “distribution induced over-stocking (Yang et al., 2009)” in terms of grassland biomass. Species composition is another important aspect to consider when assessing the quality of grasslands. Although we surveyed species composition in July 2008 within our study area, we were not able to detect the change of composition from 2000 to 2009 since no comparable data were available in 2000–2002 in the same area.

Given the significant negative impact of fences on wildlife especially the endangered Przewalski’s gazelles, it would be necessary to restrict fence building and remove a portion of fences in areas with a high density of fences. During household interviews, however, herdsmen (43 out of 46) indicated that fences were useful for managing movement of livestock, and for defining boundaries of household grazing rights to avoid conflicts among neighbors, just as Robert Frost stated “*Good fences make good neighbors*”. More than half of the interviewees were not willing to remove fences permanently. Collective grazing in small groups, which refers to collaboration among neighbors on grassland use (Li et al., 2009; Cao et al., 2009), may be encouraged with governmental incentives for herdsmen who are willing to open gates on fences or even remove fences within their pastures, to reduce the impacts of fences on wildlife without causing conflicts among neighbors. With proper managements, collective grazing may help to conserve grasslands while providing constant livestock production (Baur et al., 2013).

Compliance and ethics *The author(s) declare that they have no conflict of interest.*

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